Canada. Interdepartmental
Skilled Manpower Training
Research Committee
Report

RESEARCH PROGRAM ON THE

TRAINING OF

SKILLED MANPOWER

No. 3

TECHNOLOGICAL CHANGES AND SKILLED MANPOWER: THE HOUSEHOLD APPLIANCE INDUSTRY

Department of Labour, Canada,
in co-operation with federal and
provincial government agencies and
other groups

Research Program on the
Training of Skilled Manpower

III - TECHNOLOGICAL CHANGES AND SKILLED MANPOWER: SUMMARY REPORT ON THE HOUSEHOLD APPLIANCE INDUSTRY

The field work on which this report is based was undertaken in the summer of 1957 by Professor William Bruce of McGill University and Professor Jacques St. Laurent of Laval University. This report was prepared by the Economics and Research Branch of the Department of Labour under the general direction of the Working Committee on the Skilled Manpower Training Program.

Department of Labour, Canada
in co-operation with federal and
provincial government agencies and
other groups

September 1958

T A B L E   O F   C O N T E N T S

In the summer of 1956, a study was made of the effects of technological change in the Electrical and Electronics Industry and the Heavy Machinery Industry. The results of this study were embodied in Report No. 2 of the present series.

The present report is the result of a more intensive study of the Household Appliance Industry carried out in the summer of 1957. This industry was selected for study because, first, it is an important segment of manufacturing, employing many people; second, it is a highly mechanized mass-production industry in which technological improvements are likely to be relatively frequent; and, third, the volume of production is reasonably measurable, since it consists chiefly of a few products produced in large numbers.

Nine leading plants in the industry in Ontario and Quebec were visited and in each case several of the principal officials were interviewed. Information was obtained on technological changes in each plant in recent years and, in as much detail as possible, the effects of these changes on manpower requirements.

Data were also obtained on the composition of the working force in each plant, by function and by level of skill. This provides a valuable overall indication of both the quantitative and qualitative aspects of manpower in this industry during the summer of 1957. This information will also serve as a useful benchmark for comparison with similar data obtained in the future.

II Characteristics of the Household Appliance Industry

The chief products of the industry, as it is defined for the purpose of the present study, are as follows:

- Refrigerators, freezers, and coolers
- Air-conditioning apparatus
- Washing Machines (automatic and non-automatic)
- Driers
- Vacuum cleaners
- Floor polishers
- Ranges (electric and gas)
- Water heaters
- Oil burner pumps

Most of the products of the industry have been established in the Canadian market for a number of years. Basic changes in the designs of products have been rare in recent years; perhaps the most important example is the shift to automatic washing machines from non-automatic. Changes in the products have consisted chiefly of many small improvements in quality, in appearance, in materials, in size, and so forth.

The most important technological changes in the industry have therefore been changes in processes of production, in engineering, in materials, etc., rather than in the products.

Geographically, over 90 per cent of the industry, measured either by production or by numbers employed, is located in Ontario or Quebec.

All of the plants visited in the present survey were in one of these two provinces. Of the nine firms surveyed, six are owned or controlled by, or closely allied with, parent firms in the United States. One is owned by a European firm, and one has ties both with the United States and with Europe. Only one of the nine is an independent Canadian firm.

It follows that the great majority of the products of these firms follow designs prepared by the parent companies in the United States or Europe. These designs, however, are frequently modified to a greater or less extent to adapt them to the Canadian market or to the production methods of the Canadian plant.

The chief advantages to a Canadian firm of affiliation with a foreign parent firm, especially one in the United States, appear to be as follows:

1. The products of the firm bear United States brand names, which are already well known to the Canadian consumer through United States advertising.

2. Part of the cost of designing and engineering is spread over the output of both firms in both the United States and Canada, instead of being carried by the Canadian output alone.

3. Some component parts may be imported from the parent firm more cheaply than they can be made in Canada.

4. More abundant capital is available through the parent firm for the expansion or improvement of plants.

Some technological changes require the investment of considerable capital. This cost can be amortised more easily, the larger the volume of output.

The competition to increase sales is therefore severe. In the market for consumer durables, customers may shift rapidly from a given brand to a competing brand of the same product, if the latter offers slight or even imaginary advantages. There is constant pressure on the manufacturer to offer a product which not only is, but also appears, fully as modern as those of his competitors. Model changes tend to become more

frequent. In consequence, capital invested in tooling up for a new model must be recovered within a relatively short time. This increases the pressure to increase output and sales.

As a result of these conditions, firms which have a large volume of sales, and which can draw on an abundant supply of capital, tend to enjoy a cumulative advantage over those less favorably situated.

III Trends in Production and Employment

The production of household appliances in Canada has increased rapidly since the end of the Second World War. The trends of production and employment since 1949, for six of the nine plants included in the present survey, are shown in Table 1. The methods by which Table 1 was prepared are described in the Note at the end of this section.

The physical volume of production of the six plants, and the number of workers employed (excluding supervisory and office employees), have both fluctuated considerably between 1949 and 1957. However, the physical volume of production has shown a substantial upward trend over the nine-year period, while employment has trended downward.

It appears, therefore, that physical output per employee has followed an upward trend still more rapid than the trend of total physical output. Technological changes, in the plants studied, have had the over-all effect of reducing employment while increasing output.

Accompanying this increase in output per employee, a steady increase in investment per employee was reported by most of the firms interviewed.

In order to avoid exaggerating the precision of the indices shown in Table 1, it is necessary to bear in mind exactly what they represent.

The index of physical volume of production has been computed from the numbers of units of the principal appliances produced or shipped during each calendar year. It indicates gross rather than net output. It does not allow for increases or decreases in the percentages of materials or components purchased from other plants rather than produced in the plant itself, or in the percentage of maintenance work, toolmaking, or other work which is contracted out to other firms.

This index also makes no allowance for gradual improvement in the quality of the individual products. For this reason, it probably understates rather than overstates the upward trend in output.

The employment index is based on the numbers of production and related workers employed, and does not include supervisory and office workers. If the latter were included, the downward trend in employment over the period would still be present, but would be less pronounced. The total number of supervisory and office workers has increased absolutely over the period, and has consequently increased substantially as a percentage of total employment in the six plants. From 1949 to 1951, supervisory and office workers constituted approximately 22 per cent of total employees, and had risen to approximately 32 per cent of the total for the years from 1955 to 1957.

The group "supervisory and office employees" includes professional workers. The increase in this group thus reflects, among other factors, any increase in the employment of engineers and other professional types, as well as of factory supervisors, which has resulted from technological changes. Such a change, however, must have been small from the statistical point of view, in comparison with the changes in total numbers of plant and office employees. It appeared, therefore, that the clearest picture would be obtained if the employment index were based only on numbers of production and related workers, as has been done in Table 1.

The upward trend in production and the downward trend in employment, shown in Table 1 for the six plants covered, have probably not occurred to so striking an extent in the household appliance industry as a whole. The six plants are all above average in size, and most of them employ several hundred workers apiece. They are divided between the two industrial classifications entitled (at the date of this report) "Refrigerators, vacuum cleaners and appliances" and "Heating and cooking apparatus". In these two classifications, the total number of establishments during the last nine years has been approximately two hundred, and the average establishment has employed less than one hundred workers, including supervisory and office employees.

Total employment in these two hundred plants (including supervisory and office employees) increased by nearly seven per cent between 1950 and 1956, while that in our six selected plants decreased by approximately 12.5 per cent between the same years. (The six plants are of course included in the two hundred.)

Indices of the physical volume of production have not been published for the two industrial classifications concerned, but the information available suggests that the rate of growth of total production, for the two hundred plants together, has been somewhat less than the rate for the six selected plants, shown in Table 1.

It seems justifiable to conclude, therefore, that the trends in production and employment shown in Table 1 have not occurred to so great an extent in smaller plants in the same industrial classifications.

Table 1: Indices of Production and Employment for Six Plants Manufacturing Household Appliances, 1949-56

(1949 = 100)

Calendar Year	Physical Volume of Production	Employment, Production and Related Workers
1949..................	100	100
1950..................	146	150
1951..................	127	136
1952..................	123	120
1953..................	147	138
1954..................	137	117
1955..................	136	109
1956..................	175	117
1957..................	136	97

The future trend of production in the Household Appliance Industry may be confidently expected to be upward, perhaps more definitely so than during the years since 1950. According to projections prepared for the Royal Commission on Canada's Economic Prospects, the population of Canada was likely to increase by over 50 per cent between 1955 and 1975. The number of Canadians aged 20 to 29 - the age at which families are most likely to be formed - was expected to increase by about two-thirds. The Gross National Product was likely to be more than doubled over this 20-year period. While projections must always be used with caution, it is evident that the market for household appliances in Canada will continue to grow, perhaps more rapidly than in the past.

Whether employment in the industry will also increase, depends obviously on whether total output increases at a higher rate than output per employee.

<u>Note on Table 1</u>: These two indices were computed by the Economics and Research Branch of the Department of Labour, from data obtained by the Dominion Bureau of Statistics through its Census of Manufactures.

The data used apply to six of the nine plants surveyed by Professor Bruce and Professor St. Laurent.

The index of the physical volume of production was computed from the numbers of units of the principal appliances - refrigerators, stoves, etc. - produced or shipped by the six plants during each calendar year. Each product was weighted by its average factory price over the period - that is, by the median of the nine yearly average factory prices.

The index of physical production was adjusted to allow for the percentage of total output each year for which usable volume figures were not available. This percentage varied from year to year, between a minimum of 9 per cent and a maximum of 17 per cent of total output, by value.

The index of physical production for the last four years was also adjusted for changes in inventory of finished products, as the basic volume data for these years represented factory shipments rather than production. This adjustment would have been desirable in some cases in earlier years, but was not possible.

The employment index is based on the annual average of monthly total employment of production and related workers. Supervisory and office employees were not included.

IV Types of Technological Change in the Industry

The phrase "technological change" embraces changes of many different types. They may be divided into four categories:

1. The introduction of new products or more complicated products.

2. Changes in production processes.

3. Changes in materials.

4. Changes in organization within the plant.

Some types of technological change can be introduced at little expense. This applies especially to improvements in plant organization, such as the more efficient location of machines, or better planning of production. On the other hand, changes in products, in processes, or in materials usually require the investment of capital.

Many technological changes result, directly or indirectly, from scientific discoveries. But there is, no doubt, a great deal of scientific knowledge now in existence which could theoretically be applied in industry, but which it has not yet become economically desirable to use. The timing of technological change is determined by economic factors, such as the availability of markets or capital, as well as by the rate of scientific progress.

It is largely because of such economic factors that the rate of technological change varies greatly from one plant to another in the same industry.

In the Household Appliance Industry, technological changes of the first type mentioned - the introduction of new products or of more complicated products - have probably been less frequent in recent years than in some other industries. The major types of household appliance have been established for a number of years. Improvements in quality are made frequently, but few of these constitute a major change in the product.

Improvements in plant organization are no doubt made frequently. Among the examples noted in the plants surveyed were:

1. An improved organization of inspection, which substantially increased the output per inspector.

2. A better location of machines, which enabled one operator to tend two machines, and thus substantially reduced the number of operators required for a given volume of output.

3. The distribution of different types of engineering work among several sections, in place of the one engineering section which had previously handled all types. Thus an increased volume of engineering work could be handled.

Among changes in materials used, the most important recently has been the increasing use of plastic.

While not suitable for parts which are under heavy stress, plastic has been increasingly used for many purposes, including lining and insulation.

When it is suitable, plastic has many advantages over metal. Parts can be formed of plastic without the use of heavy, expensive presses such as are required to shape metal. Parts of intricate shape, which would have to be assembled from several pieces of metal, can be formed from plastic in one piece. Plastic is a good insulator both electrically and thermally.

The extent to which plastic may save manpower can be illustrated by the example of a food liner for a refrigerator. This part could probably be made from plastic in three operations: forming, trimming, and piercing. To make the same part from metal requires at least eight operations: shearing, piercing, forming, acid bath, welding, scale removal, cleaning and drying, and enamelling.

Plastic of course, has been replacing not only metal, but also rubber and other materials in many uses.

Among other materials which have been used increasingly in some plants are aluminum and stainless steel. Since these do not tarnish, they eliminate the need of plating, painting, or enamelling.

Two of the firms surveyed had operated foundries until 1953, when both foundries were eliminated. This was a result of the declining use of cast iron in household appliances.

Changes in processes of production - which category probably includes most of the cases of technological change which concern us in this industry - may be illustrated by the following examples:

1. More complex and more automatic machines have been introduced, which perform more operations more rapidly with less human intervention. Such machines are of many different kinds, and may perform such operations as boring, machining, facing, welding, winding electric motors, or punching, bending, or forming sheet metal.

The introduction of such machines usually reduces the number of machine operators required for a given volume of output. The operators of the new machines may not require more skill than those of the old machines, but may have more responsibility.

The more automatic machines are likely to turn out a product of more uniform quality, and therefore to reduce the labour required for inspection.

2. Transfer machines and conveyor systems have replaced much unskilled labour formerly employed in handling materials and unfinished products.

3. Automatic furnaces and ovens, employing automatic conveyor systems, have been developed for such varied purposes as annealing, enamelling, or baking insulation on electrical parts.

4. Simple assembly operations have sometimes been mechanized. The number of assembly operations has also been reduced in some cases by changes in design, such as the use of shaped plastic parts instead of metal sub-assemblies, or the introduction of magnetic locks on refrigerators.

5. Automatic spray painting, of which electrostatic spray painting is one of the more advanced types, has reduced the manpower required in painting, partly because the paint is spread more uniformly and much less touching-up is required.

The operations of cleaning and bonderizing the metal before painting are also sometimes mechanized. This reduces the labour required for handling, dipping and wiping the metal, etc.

6. Quality control and inspection methods are changing, partly because of the introduction of more advanced testing and inspection techniques, and partly because of the spread of highly mechanized or automatic processes. Such processes, by eliminating human error, furnish a product of more uniform quality, and shift the emphasis from the inspection of the product to the accurate control of the process.

There is consequently some reduction in the man-hours of inspection required per unit of product. The level of skill required of inspectors is sometimes increased.

V <u>Effects of Technological Changes on Total Manpower Requirements</u>

The effects of technological changes on manpower requirements will be discussed in this report under two headings:

1. Effects on total manpower requirements.

2. Effects on the relative requirements for different types of manpower, especially on the relative requirements for skilled, semi-skilled, and unskilled manpower.

The first category of effects will be discussed in the present section, and the second category in the two sections which follow.

These two categories of effects are, of course, closely related in real life. They represent in fact merely two different ways of looking at the same problem, since the change in total manpower requirements due to a technological change is merely the net result of all the changes in requirements, positive or negative, for particular types of manpower, which result from that technological change.

Technological changes are introduced for a number of different reasons. The motive is not always merely the reduction of cost per unit of product. Sometimes the principal purpose is to increase output substantially to supply a growing market, and the reduction of cost per unit is a secondary consideration. Sometimes the purpose is to introduce a new product. Sometimes the purpose is to improve the product, even if the cost per unit is increased, by incorporating better materials, by making the product more complex, by achieving more uniform quality, or by greater precision in production.

When the purpose of a technological change is the introduction of a new product, or the improvement of an established product, the effect may be an increase in total manpower requirements. Even if an improved product requires more man-hours of labour per unit of output than the old version, and is therefore higher priced (as in the case of the automatic washer), the public will buy it if the improvement is great enough; this is made possible by the increase in Canadian per capita income and in the Canadian standard of living.

However, in most cases of technological change, the reduction of cost per unit of output is one of the motives involved, even if it is

secondary to other purposes. The reduction of cost per unit is likely to involve in one way or another the reduction of the number of man-hours of labour required per unit of output.

Turning to the Household Appliance Industry, a considerable number of examples of the displacement of workers by technological change were discovered in the nine plants surveyed.

In one case, the introduction of electrostatic spray painting reduced the number of skilled spray painters required from six to three. The replacement of turret lathes by automatic screw machines in another plant meant the replacement of six machines by three machines, with a corresponding decrease in the number of operators, while output her hour increased enormously. In a third plant, the replacement of hand wiping by bonderizing, in preparation for painting, eliminated 8 to 10 unskilled men. In a fourth plant, the introduction of automatic winding of electric motors displaced about 20 of the 30 women previously employed on this operation. These examples have been chosen almost at random, and many more could be quoted.

However, in many cases it was found that the displaced workers had been shifted to other jobs in the same plant. One firm, which closed down its foundry in 1953, as a result of the gradual substitution of other materials for cast iron, was able to absorb about 95 per cent of the foundry workers elsewhere in the plant, partly because a new major product was introduced at about the same time.

It is necessary to take account not only of the displacement of workers in the particular production process which is changed, but also of the effects of the technological change on the demand for labour in the rest of the plant. The introduction of more complex machinery, for example, may call for an increase in the manpower employed on maintenance, in the tool room, in engineering and design, etc. This may increase the demand for skilled craftsmen, technicians, and engineers, rather than for the types of labour displaced by the machines. However, if the increase in mechanization facilitates an expansion of production, there may also be an increase in the demand for unskilled and semi-skilled labour in some parts of the plant.

The number of jobs available in other plants and other industries may be affected in various ways by technological changes in a given plant. The reduction in the cost of production in the given plant may enable it to expand its sales and perhaps to employ more workers rather than fewer; but at the same time, it may put one or two weaker competitors out of business.

On the other hand, the plant which has made the changes may now provide an increased market for suppliers of materials, parts, tools, machinery, or maintenance services, and may thus increase employment in these allied industries.

The total effect of technological change on employment in six selected plants over a period of nine years is shown in Table 1. For the six plants included, between 1949 and 1957, while production increased by 36 per cent, employment (not including supervisory and office employees) decreased slightly. If the two peak years of 1950 and 1956 are compared, the contrast between increasing output and decreasing employment is still more striking.

However, a gradual reduction in the number of jobs available in a plant, due to technological progress, does not necessarily result in heavy layoffs. The normal turnover of employees may be great enough to enable this reduction to be made merely by not hiring replacements for those who leave, without any actual layoffs of employees. This means, of course, that some people who would under former conditions have obtained jobs in this particular plant are now no longer able to do so. The impact of displacement is thus passed on from the actual employees of the plant to this anonymous group outside, which may consist of young people entering the labour force, of those currently unemployed from other causes, or of older people or others who are marginal members of the labour force.

These people who are indirectly affected by displacement, will not feel the impact at all, if the economy is growing and employment in general is expanding rapidly. At such a time, the impact of displacement may be dissipated without perceptibly affecting anybody.

In actual fact, during the last decade, the rapid growth of the Canadian economy has both encouraged technological change, and made its effects easier to absorb. The Canadian economy, during the last decade considered as a whole, has been distinguished by increasing population, increasing demand for goods and services, increasing production to meet this demand, an increasing labour force, and increasing employment.

The volume of output per capita has also been increasing, largely because of technological changes. Real income per capita has consequently increased. The average Canadian has been able to obtain increasing quantities of an increasing variety of goods and services. The Canadian market has been able to absorb an increasing output of most established products, and also a number of new products which have been developed.

It seems likely, therefore, that the problem of the displacement of manpower by technological change would have been almost negligible, if the growth of the Canadian economy had proceeded at an even rate year after year. Unfortunately, as is evident in Table 1, production and employment in the manufacture of household appliances have fluctuated considerably from year to year.

It is impossible, when employment decreases substantially, as it did, for example, between 1953 and 1954, to estimate how much of the decrease is due to technological changes and how much to a decline in sales. If technological changes in a given plant have not resulted in layoffs, but only in a decrease in hirings, there are no specific individuals who can be identified as technologically unemployed. The technological displacement of workers is merged indistinguishably with the cyclical and seasonal factors tending to produce unemployment at the same time.

Moreover, the difficulty of distinguishing technological unemployment from cyclical unemployment may be increased by a lag in the manpower effects of technological change. When a technological change is made in a given plant, the manpower economies which result may not be fully realized for several months. Consequently, if this plant has introduced technological changes during a period of prosperity, and then lays off workers during the following recession, it is difficult to determine whether these workers are cyclically or technologically unemployed.

The different levels of skill, and the different ways in which they are affected by technological change, will be discussed in later sections of this report. It should be mentioned here, however, that the majority of the workers displaced by technological change are unskilled or semi-skilled - machine operators, handlers of materials, etc. To some extent, this makes it easier to deal with the problem of displacement, since about three-quarters of the jobs in the average plant are unskilled or semi-skilled, and therefore it is usually possible to transfer some or all of the displaced workers to other jobs at the same skill level with little retraining.

If skilled workers are displaced, the problem of retraining and transferring them may be more complex. It may be difficult for such workers to find jobs, either in the same plant or elsewhere, at the level of skill and with the same status which they had formerly achieved. However, a worker possessing a skill for which there is a wide demand is likely to find another job, even in a different industry, which he can fill with little retraining.

VI Levels of Skill in the Working Force

The effects of technological changes on relative requirements for different types of manpower, and for different levels of skill, are perhaps equal in importance to their effects on the total demand for manpower. For example, in planning policy on vocational training, it is important to develop as clear an indication as possible of those types of skill which will be required in increasing quantities in the future.

One broad result of technological changes appears to be a decrease in the demand for manpower for direct production processes - machine operators, for example - relatively to the demand for indirect plant labour, i.e., workers in maintenance, the toolroom, engineering.

Such a trend is likely to mean a relative increase in the demand for skilled workers, as the percentage of skilled workers in the engineering, maintenance, or toolroom divisions of the plant is always considerably greater than among the direct production workers.

This statement is based on the data shown in Tables 2, 3, and 4. These figures were obtained from the firms surveyed, and apply of course to the summer of 1957.

Comparable data for earlier dates were not available in most cases, but comparable data may be obtained at suitable dates in the future for comparison with those secured in 1957.

Table 2, based on data from eight of the nine firms surveyed, shows the average composition of the working force by function or by plant division, in percentages.

Direct production workers make up 50 per cent of total employment, the other 50 per cent including management, office workers, and sales personnel, as well as indirect plant labour.

Table 3 is based on data from four of the firms surveyed. It shows the average composition by level of skill, of the working force in direct production, engineering, production planning and control, maintenance, the toolroom, and ancillary plant services - that is, in all divisions except management, office, and sales.

An explanation of what is meant by "highly skilled", "skilled", "semi-skilled", and "unskilled" is given in a note at the end of this section.

Table 2: Employment by Division:
Eight Plants in Household Appliance Industry

Division	Percentage of Total Employed
Management.	6%
Office.	12
Sales.	7
Engineering.	4
Production Planning and Control (including inspection).	6
Production.	50
Maintenance.	4
Toolroom.	3
Ancillary (shipping, receiving, stores, etc.)...	8
Total.	100%
Approximate total number employed, June-July,1957	5,400

Table 3: Employment by Level of Skill: Four Plants in Household Appliance Industry

Level of Skill	Percentage of Employment (a)
Engineers (b)	1.2%
Highly skilled	7.2
Skilled	14.5
Semi-skilled	38.0
Unskilled	39.1
Total	100.0%
Approximate total number of employees included	2,200

(a) Includes employees of all categories shown in Table 2 except management, office, and sales.

(b) University graduates or equivalent.

Table 4: Employment by Division and Level of Skill: Eight Plants in Household Appliance Industry

Level of Skill	Production %	Maintenance %	Toolroom %
Highly skilled.........	2	19	40
Skilled...............	11	48	50
Semi-skilled..........	48	8	10
Unskilled.............	39	25	
Total.................	100	100	100
Approximate total number of employees..........	2,700	200	160

NOTE: Figures collected on the following division were not sufficiently complete to warrant their inclusion in the table:

Engineering: This division includes a high percentage of skilled or highly-skilled workers. Of those doing engineering work, not all are university graduates, but the rest would probably rate as highly-skilled. There are many draftsmen at the skiiled or highly-skilled level, and such other types of skilled worker as model makers or process planners.

Production Planning and Control: This division includes some highly-skilled workers in such fields as methods planning. The largest group in the division, however, is the inspectors, the majority of whom are rated as semi-skilled.

Ancillary Workers (shipping, receiving, stores, etc.): the large majority are unskilled.

Table 3 shows that the unskilled and semi-skilled, on the average for the four plants included, represented 77 per cent of the total direct and indirect production workers.

The divisions in which these unskilled and semi-skilled workers were chiefly located, and those in which the skilled and highly skilled were located, are shown in a broad way in Table 4. This table is based on data from eight plants.

This table (with its note) shows that the skilled and highly-skilled plant workers are largely concentrated in the following divisions: engineering, maintenance, toolroom, and certain functions under production planning and control. The semi-skilled and unskilled are chiefly concentrated in production, inspection, and ancillary services.

Note: Definition of the Different Grades of Skill

In the course of the 1957 survey of nine leading plants, the employees, in divisions other than management, office, and sales, were classified into the four grades "highly skilled", "skilled", "semi-skilled", and "unskilled". This was done through consultation with officials of the plant, usually personnel managers, and on the basis of the occupational categories appearing on the plant's payroll. The following list gives some of the more important occupational groups included in each of these four categories:

A. Highly skilled:

1. Tool and die makers, patternmakers, and tool repairmen.
2. Production workers setting up and operating exceptionally complex equipment.
3. Maintenance workers, such as electricians, electronics technicians, mechanics, pipefitters, etc., if doing work requiring exceptional skill.
4. Workers on quality control who apply advanced inspection techniques.
5. Technicians assisting in design, the making and testing of models, production planning, and other types of work in engineering or related fields, but below the professional level.
6. Some draftsmen working on design.
7. A substantial proportion of the lead hands.

B. Skilled

1. Most set-up men.
2. Operators of complex machines or equipment, usually also setting up the machines.
3. Production workers in skilled trades, such as skilled welders and brazers, spray enamellers, spray painters doing touch-up or finishing operations, etc.
4. Maintenance men and repairmen in skilled trades, such as most electricians, fitters, millwrights, pipefitters, painters, etc.
5. Skilled tradesmen employed on engineering work.
6. Most draftsmen.
7. Inspectors applying reasonably advanced techniques.
8. Some lead hands.
9. Apprentices in skilled trades.

C. Semi-skilled:

1. Most machine operators, including welders who operate welding machines.
2. Certain other production occupations, such as metal finishers and polishers, platers, ordinary spray painters, etc.
3. Many inspectors.
4. Some storekeepers.

D. Unskilled:

1. Assemblers.
2. Miscellaneous machine and bench workers.
3. Inspectors applying simple routines.
4. Most storekeepers.
5. Packers, loaders, and other handlers of materials and products.

VII Effects of Technological Changes on Skilled Requirements

The effects of technological changes on requirements for different types of skill can best be shown by considering in turn the various divisions of work in the plant: production, engineering, maintenance, the toolroom and quality control.

1. Direct Production

It is here, on the production lines, that human workers are most likely to be replaced by machines. The repetitive types of work which occur on production lines are the types of work most suitable for mechanization.

Not all parts of the production line are equally suitable for mechanization. The machining or processing of a certain part is usually easier to mechanize than the assembly of several parts into a product. Machine operators are therefore more likely to be displaced than assemblers. Unskilled handlers of materials are frequently replaced by conveyor systems.

The number of skilled workers displaced by technological changes appears to be much smaller, relatively to the total number of skilled workers employed, than the number of unskilled or semi-skilled.

Do technological changes result in changes in the type of worker required on the production line? Do the new, more complex machines require more highly skilled operators? In this respect, the effects are varied. Examples can be found in which the new process requires a higher level of skill than the old. On the other hand, it is stated by some managers that the average level of skill required of production workers is decreasing as processes become more automatic.

It appears dangerous to generalize on this point. However, whether or not a higher level of skill is required, the demands on the worker may increase in other ways. The newer processes of production have a higher output per hour, and the rhythm is usually less flexible. Each worker supervises an increased quantity of equipment. The cost of a single mistake is therefore likely to be greatly increased. The worker may therefore be required to show greater alertness and a greater sense of responsibility.

2. Engineering

The engineering functions to be performed in a plant may include product design, tool design, planning of production and methods, installation of machines and equipment, and quality control. These varied functions may be distributed in different ways between divisions in the plant.

An increase in these functions will call for increased numbers, not only of engineers, but also of highly-skilled technicians, and draftsmen, among other types of worker.

The number of engineers employed in Canadian industry has for many years been increasing more rapidly than the total number of employees.

According to Census figures, the number of engineers per 1,000 employees in Canadian industry was 3.8 in 1931, and had risen to 6.0 in 1951.

Reasons for such a trend are not hard to find. First, there is the rapid growth in Canada of such technically complex industries as the manufacture of aircraft or electrical apparatus, or the metallurgical or chemical industries. Second, there is the rapidity of technological progress which now frequently means the increasing application to industry of the results of scientific research.

The products of the Household Appliance Industry are relatively simple, in comparison with such products as aircraft or heavy machinery. Household appliances are also mass-produced in runs of thousands of similar units. The amount of engineering required in designing the product is therefore less, relatively to the value of the output, than in some other industries.

In addition, Canadian appliance plants, in most cases, obtain the basic designs of their products from parent firms in the United States or Europe. The proportion of the product designing done in Canada varies from 100 per cent, in the case of the few independent Canadian firms, to almost zero, when detailed blueprints are imported from the parent firms. For most Canadian plants, the proportion probably does not approach either of these extremes. In some well-established Canadian branch plants, the tendency in recent years has been to increase the percentage of the designing done in Canada. There has also been the opposite tendency for Canadian firms, previously independent, to become allied with foreign firms and to obtain their product designs from them.

Related to the importing of product designs is the tendency to import from the United States such components as are very difficult to make, or require expensive equipment and long production runs. With the growth of Canadian production, there has been a trend toward reduction of the number of components imported. In some cases, by altering the design, or changing the material (e.g. substituting plastic for metal), it has been made easier to produce a component in Canada.

The net result of all these conflicting tendencies has been an increase in the number of trained workers required for product designing in the industry in Canada. This trend is due especially to technological advances in the products and in the methods of production, which tend to call for more detailed design and the preparation of more detailed drawings.

Nevertheless, a larger proportion of engineering activity in the Canadian industry is concerned with plant operations such as production planning, the installation of machines and equipment, the development and

improvement of factory methods, tool design, and the introduction of alternative materials. The volume of such work tends to increase because of the introduction of more complex machines and processes, and of more highly integrated production lines, which require more exact planning and timing.

In comparison with some other industries, relatively few graduate engineers are employed in the household appliance industry. Among the nine plants surveyed, those employing the largest numbers of engineers were some of the branch plants of United States firms, and not, as one might expect, those plants which were most independent of external control and imported designs.

However, as a result of technological advances and of some of the other trends which have been mentioned, it seems probable that requirements for engineering personnel will increase in the industry more rapidly than the total number of employees. This means an increasing demand, not only for engineers, but also for highly-skilled engineering assistants, for draftsmen, and for various other types of highly trained manpower, such as model makers or process planners.

3. Maintenance

The more complex machinery and equipment in manufacturing plants, resulting from technological change, requires increased maintenance. Preventive maintenance is becoming increasingly desirable, in view of the high cost of a breakdown on an integrated production line, which represents a heavy investment.

According to Table 4, about two-thirds of the maintenance workers are rated as skilled or highly-skilled. The increase in maintenance work may therefore be expected to increase the relative demand for workers at the higher skill levels.

The level of skill required of maintenance workers is also rising, because of the increasing complexity of equipment. In addition to electricians, there is now a demand for electronic technicians. In addition to plumbers and steamfitters, men are required who understand hydraulic and pneumatic systems. Maintenance welders must be able to deal with a greater variety of metals and with new techniques.

Some firms have arranged courses in electronics and other subjects in recent years, to raise the levels of skill of their maintenance workers.

In some cases, part of the maintenance work is contracted out. This is usually a type of work which comes in large volume and is not highly technical. The more specialized work is usually handled by the firm's own staff. However, the contracting-out of some work makes it difficult to obtain figures showing the increase in man-hours required for maintenance.

4. The Toolroom

Labour in the toolroom, according to Table 4, is about 90 per cent skilled or highly skilled. Even if this figure should be exaggerated, it is evident that an increase in the manpower employed in toolmaking, relatively to direct production manpower, would mean an increase in requirements for skilled and highly-skilled labour, relative to unskilled and semi-skilled.

It appears that technological changes in the Household Appliance Industry are in fact bringing an increase in the proportion of total plant labour employed in toolrooms. More complex machines reduce the number of machine operators required, but increase the number of tools needed. More frequent model changes require more frequent changes of tools and dies. The decreasing use of cast iron and the substitution of sheet metal or other factors tending to increase or perhaps decrease the demand for tools in the various plants. But the general consensus is that the volume of toolroom work is increasing.

The increased speed of the new machines requires tools of better quality. On the other hand, the frequency of model changes creates a demand for cheaper tools and dies, of shorter life. The effort to reduce the cost of tools and dies stimulates the use of plastic and other materials more malleable than iron and steel.

The increase in employment in toolmaking does not all appear in the payroll data of the firms surveyed, as few of these firms design and make all of their own tools, although tool maintenance is generally done in the plant's own toolroom.

As examples of the variations in practice, it is possible to mention one firm which designs and makes nearly all of its own tools, as well as making tools on contract for other firms, and to mention another plant which obtains all its tool designs in finished form from its parent firm in the United States.

Since the introduction of a new model of the product requires the making of a large number of tools within a short period, most firms find it uneconomic to produce all of their own tools. A greater or smaller proportion of the toolmaking - sometimes all of it - is therefore contracted out to toolmaking firms. In some cases some of the tool designing is also contracted out.

This is one of the ways in which technological changes in the Household Appliance Industry tend to create increased employment in other plants - in this case, increased employment especially for skilled and highly-skilled labour.

5. Quality Control

Inspectors form an important group of employees in the Household Appliance Industry. The majority of them, in the present survey, have been rated as semi-skilled. It seems probable that, for this group also, requirements are changing gradually as a result of technological changes..

Three trends may be distinguished:

1. As production becomes more mechanized and more automatic, the opportunities for human error are reduced, the product becomes more uniform, and the work of inspection is reduced. Less effort is devoted to inspecting component parts, and more to the accurate checking of machines and processes. In a plating shop, for instance, instead of inspecting plated parts, a closer analysis is made of the solution, and a closer check of temperature and current; the number of inspectors required has thus been reduced from five to one.

2. The methods of inspection themselves are subject to technological change, and are becoming more scientific. For example, better use is made of statistical methods; by careful sampling, the need for 100 per cent inspection of component parts is being eliminated.

The new inspection techniques in some cases require a more highly qualified inspector.

3. By better organization of the work, the number of inspectors required for a given output can sometimes be reduced.

To sum up, there appears to be a gradual tendency toward the employment of somewhat fewer but somewhat more skilled inspectors, for a given level of output.

VIII Office Mechanization

Nearly all the plants surveyed had equipped their offices with electrically-controlled calculating and other machinery. It was stated that the introduction of these machines had resulted only in small reductions, or sometimes in no reduction, in office staff.

The machines, however, make a much greater volume of information available to management than would be possible otherwise without a great increase in office staff.

In addition, even a much larger office staff would in many cases be unable to provide the information so rapidly as the machines, or to keep accounts and payroll data so up to date.

Without the machines, therefore, there would probably have been a much greater increase in employment for office workers, but the work would have been done less efficiently.

IX Conclusions

While the conclusions of this study cannot be expressed precisely in statistics, the following broad statements seem to be justified:

1. There are many different kinds of technological change, including the introduction of new or improved products, new processes, new materials, and improved organization. Change proceeds at different rates in different plants, largely because of the differing economic positions of the firms concerned.

The most important changes, which require the investment of considerable capital, tend to be introduced in those plants which have a large volume of sales and access to large reserves of capital. Access to foreign designs and foreign engineering may also be an important advantage. The technological changes are likely to strengthen further the position of these plants relatively to their competitors.

The plants which are in a weaker position and which cannot afford major technological changes are likely to be forced by the strenuous competition in the Household Appliance Industry into such alternative courses as, for example, to shift to less competitive products outside the household appliance field, to concentrate on one or two specialties for which they have an established reputation, or to join with a stronger firm outside Canada.

It seems probable that there will be continued trends toward a higher degree of mechanization and a greater volume of production from the individual plant.

2. In recent years, while the physical volume of production has been increasing, the number of production workers employed, by the plants included in the present survey, has been decreasing. Output per employee has been increasing as a result of technological changes.

Few employees have been laid off as a direct result of technological changes. However, when layoffs occur during periods of business recession, it seems possible that they may be due in part to earlier technological changes, rather than due entirely to market conditions.

3. Employers in most cases have planned the introduction of technological changes in such a way as to minimize the displacement of employees. It is desirable to continue this policy, and to provide for the retraining of displaced employees when this is required to fit them for other jobs.

4. The proportion of manpower employed in direct production tends to be reduced by technological change, relatively to the proportion employed in such functions as engineering, quality control, maintenance, and tool-making. These latter functions require a much higher percentage of skilled and highly-skilled manpower than direct production. The relative demand for skilled and highly-skilled manpower is therefore increasing.

5. In such functions as maintenance, the level of skill required is rising, chiefly because of the need for more theoretical knowledge of such subjects as electronics, hydraulics, or metallurgy.

6. The volume of engineering work done in Canadian plants is increasing, in spite of the widespread use of imported designs.

7. The mechanization of office work has been proceeding perhaps still more rapidly than that of production. However, this has been accompanied by a rapid increase in the volume of office work, and in the variety of data required by management, and the rapidity with which it is processed. Total office employment has been increasing in the plants surveyed, unlike production employment.

8. In several fields, including engineering, maintenance, quality control, office work, and others, there is an increasing demand for workers trained to higher levels than in the past. There is especially a demand for more intensive training in such abstract fields as mathematics, physics, chemistry, metallurgy, electronics, or hydraulics. This fact is important in the planning of future vocational training.